Development of Engineered Ceramic Matrix Composites

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Purpose: The overall objective of this proposal is to develop a new class of high temperature, lightweight, self-healing, SiC fiber-reinforced ceramic composites. The objectives of Phase II are (a) to further optimize the compositions and properties of promising engineered self-healing matrices down selected in Phase I; (b) to develop engineered matrices with self-healing capabilities; and (c) fabricate self-healing Engineered Matrix Composites (EMCs) for 1588 K (2400 °F) and 1755 K (2700 °F) applications.

Background

Although nickel-base superalloy blades and vanes have been successfully used in aircraft engines for several decades, there has been an increased effort to develop higher temperature, lighter weight, creep-resistant materials that can operate at higher gas turbine operating temperatures and reduce or eliminate cooling air in such engines. The current effort is largely focused on developing silicon carbide (SiC) ceramic matrix composites (CMCs) reinforced with silicon carbide fibers with a primarily Si matrix. These CMCs exhibit a higher damage tolerance than monolithic SiC. The SiC/SiC CMCs, with a density 1/3 that of nickel-base superalloys, offer at least a 222 K (400 °F) increase in temperature capabilities beyond the current state-of-the-art (SOA) superalloys. Current generation SiC/SiC ceramic matrix composites (CMCs) are typically designed to operate below the matrix cracking stress (i.e. the proportional limit) since the formation of surface-connected cracks would lead to an ingress of oxygen and moisture resulting in the oxidation of the BN coating on the fibers. The oxidation of the BN coatings would limit the usefulness of CMCs well below their theoretical load-bearing capabilities. The proposed effort is focused on developing a new matrix material, which exhibits high temperature plasticity sufficient to reduce crack propagation and provides a self-healing mechanism to fill surface-connected cracks to prevent the ingress of oxygen to the fibers. A matrix engineered with these capabilities is expected to increase the load bearing capabilities of SiC/SiC CMCs at high temperatures.